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Interactive Courseware Standards

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The Navy is in the process of developing interactive courseware (ICW) standards that can be used by the Navy training community to develop ICW. This report surveys existing applicable government and industry standards and emerging technologies, and describes how they related to Navy ICW development. Information is provided on existing DoD and Navy standards, operating systems, programming languages, multimedia peripheral interfaces, integrated multimedia, graphic display software, windowing software, optical disc technology, data storage and compression, and document processing. Recommendations are provided for the Navy's ICW community and for those who set the Navy's policies on ICW.

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Foreword

The Navy is currently setting standards for interactive courseware (ICW). The Chief of Naval Operations (OP-11) has chartered a committee to investigate ICW standards. This report was prepared for the Navy interactive courseware (ICW) subcommittee on hardware/software/ courseware standards and funded by Program Element 0605798D. It was developed as part of Contract N66001-88-D-0054, Delivery Order 7J48.

The purpose of the report is to survey existing applicable government and industry standards and emerging technologies, to describe how they relate to Navy ICW development, and to provide recommendations for consideration by Navy ICW policymakers.

We want to thank the researchers at the Computer Systems Laboratory of the National Institute of Standards and Technology (NIST) for their help in identifying some of the data contained in this report.

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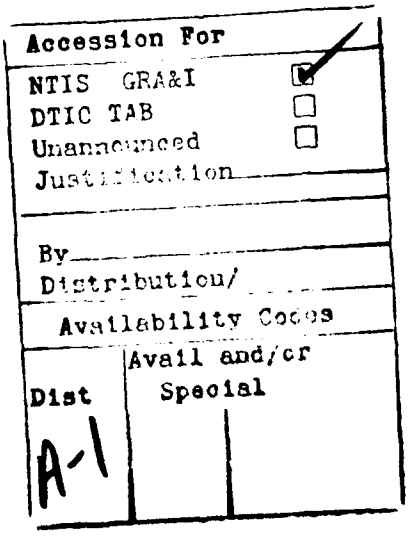

Summary

The Navy is in the process of developing interactive courseware (ICW) standards that can be used by the Navy training community to develop ICW. This report surveys existing applicable government and industry standards and emerging technologies, and describes how they relate to Navy ICW development. Information is provided on existing DoD and Navy standards, operating systems, programming languages, multimedia peripheral interfaces, integrated multimedia, graphic display software, windowing software, optical disc technology, data storage and compression, and document processing.

Recommendations are provided for the Navy's ICW community and for those who set the Navy's policies on ICW.

Contents

Introduction

Purpose

The Navy is in the process of developing interactive courseware (ICW)[1] standards that can be used by the Navy training community in the course of developing ICW for use in all aspects of Navy training. By using standards for development of ICW training systems, courseware can operate different computer systems. This results in increased use of the courseware. This report was developed to aid Navy ICW policymakers in selecting appropriate standards for ICW development. It surveys existing standards, describes how they are applicable to Navy ICW development, and offers recommendations for adoption of standards.

These recommendations are provided for Navy review and analysis. The official adoption and implementation of any standards will have to be carried out by the Navy.

Background

Many multimedia and ICW technologies exist. Some of these hardware and software technologies are well developed (mature) and others are just now being introduced for use in training systems and other applications. Standards are not available for all technologies that are used in training systems.

Several standards organizations are involved in developing hardware and software standards. At the Federal Government level, the Department of Defense (DoD) produces Military Standard (MIL-STD) documents describing the hardware and software requirements of systems developed for military use. Some of these standards are developed for specific military applications (e.g., weapons systems or training systems) and others apply to almost all computer system development done for the military. The National Institute of Standards and Technology (NIST) produces Federal Information Processing Standards (FIPSs) that apply to all branches of the Federal Government. NIST also provides guidelines and profile reports that help federal agencies in their acquisition of computer technology. The DoD often adopts existing FIPSs.

At the national level, many standards organizations work with hardware and software manufacturers to produce computer system standards. These organizations include the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), and the National Interface Standards Organization (NISO).

These organizations, in turn, work with international standards groups to develop standards used worldwide. These organizations include JTC1, the main international standards group; the International Standards Organization (ISO); the International Electrotechnical Commission (IEC); and the Consultative Committee on International Telegraph and Telephone (CCITT).

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[1] ICW refers to computer-based instruction, in most cases using microcomputer systems, that is controlled by student interaction with the instructional programs. ICW systems include lesson authoring systems and computer-based simulations. For the purposes of this report, ICW does not include full-scale simulators.

De facto standards also exist. These are based on a particular product developed by a manufacturer. Even though a de facto standard is not usually endorsed by any of the recognized standards organizations, it gains acceptance through wide use. A notable example of a de facto standard is Microsoft Corporation's MS-DOS operating system.[2] Even though MS-DOS was never approved by a standards organization, it has achieved the status of a standard microcomputer operating system. Other vendors have now developed functionally identical systems or "clones" of MS-DOS that they market as being compatible with the "MS-DOS standard." These are called MS-DOS-compatible in this report.

Other organizations are interested in portability and in developing standard environments. The Open Software Foundation (OSF) is a consortium of manufacturers that is developing a portable environment called X/OPEN. The environment is based on a portable operating system called OSF/1. NIST also supports portable environments and has drafted an Application Portability Profile to provide guidance for Federal agencies making hardware and software purchases.

Approach

This report looks at two aspects of portability standards as they relate to ICW: (1) existing military standards, directives, and instructions that apply to ICW systems, and (2) hardware and software technologies that are not yet covered by military standards but may have standards developed by national standards organizations or multimedia industry developers. Each section of the report focuses on a particular technology, including:

- Operating systems
- Programming languages
- Multimedia peripheral interfaces
- Integrated multimedia
- Graphic display software
- Windowing software
- Optical disc technology
- Data storage and compression
- Document processing

In compiling the information contained in this report, several sources of information (listed in the appendix) were used. A primary source was an on-line database of standards information that covers DoD standards and specifications, Air Force and Navy aeronautical standards, DoD

[2]Identification of software and specific equipment is for documentation only and does not imply endorsement.

handbooks, General Services Administration (GSA) standards, and U.S. standards developed by private sector organizations.

Researchers at the Computer Systems Laboratory at NIST were also a valuable source of information. Information for this report was also obtained from the Center for Acquisition of Learning Systems; product vendors, including Intel Corporation, Sun Microsystems Inc., and Reference Technology; periodicals; books on multimedia technology; and electronic news groups.

Findings

DoD and Navy Standards

Many military standards, directives, and instructions apply to software development, information resources, and computer equipment acquisitions. While all specify requirements for computer system development, only Military Standard 1379D (MIL-STD-1379D) (DoD, 1990) provides guidelines for ICW system development. It is the primary DoD standard for development and acquisition procedures for military training systems. Training systems developers should use it as the primary guide for developing courseware for the military.

MIL-STD-1379D, *Military Standard for Military Training Programs*

MIL-STD-1379D was approved on 5 December 1990, and was mandated in DoD Instruction 1322.20 of 14 March 1991. It provides requirements and guidelines for developing military training programs and information on many aspects of training program development:

1. The standard provides task descriptions for management, analysis, design, development, and support of training programs.

2. Appendix A of the standard provides guidance in developing military training programs that comply with MIL-STD-1379D. This includes information on tailoring contract statements of work and contract data requirements lists for particular training programs.

3. Appendix B of the standard provides an overview of the ICW development process, including a matrix of ICW development products, deliverables, and supporting task descriptions.

4. Appendix C of the standard defines the style and format, electronic media, and front matter requirements for military training programs. It specifies development of electronic information in compliance with the Computer-aided Acquisition and Logistic Support (CALS) standard (MIL-STD-1840B [DoD, 1988]).

5. Appendix D of the standard provides requirements for software interfaces and related commands to ensure ICW and authoring system portability on interactive video delivery systems.

Because this report focuses on hardware and software technology standards, the section of MIL STD-1379D that is most applicable is Appendix D, which describes a standard software interface for ICW systems. The standard interface is based on the *Recommended Practices for Multimedia Portability* (Interactive Multimedia Association, 1990). The Interactive Multimedia

Association (IMA) is a non-profit industry association that promotes multimedia technologies and develops standards that provide portability for multimedia-based applications. Except for formatting and specific wording used in the two documents, Appendix D of MIL-STD-1379D and the *IMA Recommended Practices for Multimedia Portability* (IMA, 1990) are the same.

The software interface described in MIL-STD-1379D, Appendix D provides a hardware-independent set of commands for controlling videodisc players, graphics overlay cards, and pointing devices (e.g., the mouse). The interface is designed for use with MS-DOS-compatible systems and is programming language independent. An application that uses the standard interface can run on any computer system that provides the management software for processing the interface commands. In this way, portability is achieved across a variety of hardware platforms.

Because MIL-STD-1379D mandates the use of this software interface for ICW training systems, Appendix D should be the cornerstone of any standards adopted by the Navy ICW community. The standard has many advantages over other portability solutions that have been proposed:

1. Since most existing ICW systems are designed to run on MS-DOS-based computer equipment, the standard solves portability problems for a large class of training systems.

2. By specifying a standard software interface instead of requiring use of a specific hardware system (e.g., the Army's standard Electronic Information Delivery System [EIDS]), it allows courseware to run on more computer platforms.

3. Because the standard is based on an industry-supported standard (IMA, 1990), instead of a DoD-developed standard, it will have greater support from manufacturers. IBM Corp., Intel Corp., and several other large manufacturers recently pledged their support for the standards being produced and the standards process being used by the IMA.

4. Because the IMA plans to enhance the standard to include other operating systems and other multimedia technologies, the DoD will benefit by adopting a standard that will be evolving with the technology.

Other Official Military Guidance

Other DoD and Navy standards, instructions, and directives that apply to training systems development were reviewed for applicability to ICW development and to determine if they conflict with MIL-STD-1379D. The research failed to find any such conflicts. A summary of relevant MIL-STD and DOD-STD documents, DoD instructions and directives, Secretary of the Navy (SECNAV) and Chief of Naval Operations (OPNAV) instructions, and the relationship of each to MIL-STD-1379D is given below:

DoD Instruction 1322.20. *Development and Management of Interactive Courseware (ICW) for Military Training* (DoD, 1991). Mandates use of MIL-STD-1379D and establishes procedures for archiving ICW in the Defense Instructional Technology Information System (DITIS) database. This instruction includes specific requirements to guide ICW developers.

DoD Directive 5000.2, *Ada Programming Language* (DoD, 1991). Mandates the use of the Ada Programming Language for most new defense systems software development. The details of the Ada programming language are documented in MIL-STD-1815A (DoD, 1983). Since MIL-STD-1379D does not specify the use of any specific programming language, it does not conflict with the requirements of this directive. However, specific action may still be required by ICW developers to comply with the requirements of this directive.

DoD Directive 7740.1, *DoD Information Resources Management (IRM) Program* (DoD, 1983). Sets forth guidelines for management of automated information systems, data elements, information technology, and information security. Since MIL-STD-1379D does not provide IRM guidelines, it does not conflict with the requirements of this directive. However, specific action may still be required by ICW developers to comply with the requirements of this directive.

DoD Directive 7750.5, *Management and Control of Information Requirements* (DoD, 1986). Provides general goals and strategies for information collection, storage, and management. This directive focuses on information management, not training or computer technology, and therefore is probably not applicable to ICW training systems. Since MIL-STD-1379D does not provide information management guidelines, it does not conflict with the requirements of this directive. However, specific action may still be required by ICW developers to comply with the requirements of this directive.

DoD Directive 7750.5-M, *DoD Procedures for Management of Information Requirements* (DoD,1986). Related to the DoD Directive 7750.5. This directive provides specific procedures for information collection, storage, and management. It focuses on information management rather than on training or computer technology and therefore is probably not applicable to ICW training systems. Since MIL-STD-1379D does not provide information management guidelines, it does not conflict with the requirements of this directive. However, specific action may still be required by ICW developers to comply with the requirements of this directive.

DOD-STD-7935A, *Automated Data Systems (ADS) Documentation Standard* (DoD, 1988). Describes documentation requirements for Automated Data Systems (ADS). Since MIL-STD-1379D does not discuss documentation requirements for ADS, it does not conflict with the requirements of this standard. However, specific action may still be required by ICW developers to comply with the requirements of this standard.

MIL-STD-2167A, *Defense System Software Development* (DoD, 1988). Provides guidelines for software engineering, software development processes, and documentation requirements for Mission-critical Computer System software. Since MIL-STD-1379D does not provide software engineering guidelines, it does not conflict with the requirements of this standard. However, specific action may still be required by ICW developers to comply with the requirements of this standard.

OPNAVINST 5200.28, *Life Cycle Management of Mission-critical Computer Resources (MCCR) for Navy Systems Managed Under the Research, Development, and Acquisition (RDA) Process* (Office of Chief of Naval Operations, 1986). Provides guidance for life cycle management of computer resources. Since MIL-STD-1379D does not provide life cycle management guidelines for computer resources, it does not conflict with the requirements of this instruction. However,

specific action may still be required by ICW developers to comply with the requirements of this instruction.

OPNAVINST 5230.22, *Manpower, Personnel and Training (MPT) Information Resources Management (IRM) Program* (Office of Chief of Naval Operations, 1986). Establishes policies, strategies, responsibilities, and a framework for meeting MPT information requirements. This instruction provides planning, acquisition, and management guidelines for Information Resources (IRs). Since MIL-STD-1379D does not provide information resource management guidelines, it does not conflict with the requirements of this instruction. However, specific action may still be required by ICW developers to comply with the requirements of this instruction.

SECNAVINST 5230.8, *Information Processing Standards for Computer (IPSC) Programs* (DoN, 1982). Promotes standards for system compatibility, machine-independent software, efficient use of automated data processing (ADP) equipment, and software portability. This instruction defines high-order programming languages to be used for ADP programming. The list of approved high-order languages includes Ada, Pascal, FORTRAN, COBOL, and BASIC. MIL-STD-1379D implements some of the objectives of this instruction, and does not conflict with any of the requirements of this instruction. However, specific action may still be required by ICW developers to comply with the requirements of this instruction.

SECNAVINST 5230.9A, *Information Resources (IR) Program Planning* (DoN, 1985). Provides IR planning and management guidelines. Since this directive focuses on information management rather than on training or computer technology, it is probably not applicable to ICW training systems. Since MIL-STD-1379D does not provide information management guidelines, it does not conflict with the requirements of this instruction. However, specific action may still be required by ICW developers to comply with the requirements of this instruction.

SECNAVINST 5230.10, *Department of the Navy (DoN) Strategic Plan for Managing Information and Related Resources (IRSTRATPLAN)* (DoN, 1987). Provides guidance for managing information, information systems, computer resources, other information technologies, and related resources. Since MIL-STD-1379D does not provide information management guidelines, it does not conflict with the requirements of this instruction. However, specific action may still be required by ICW developers to comply with the requirements of this instruction.

SECNAVINST 5231.1B, *Life Cycle Management (LCM) Policy and Approval Requirements for Information System (IS) Projects* (DoN, 1985). Provides LCM and purchasing guidelines for IS projects. Information systems are collections of people, equipment, and facilities operating to collect, refine, combine, communicate, store, or retrieve information. Since MIL-STD-1379D does not address LCM issues, it does not conflict with the requirements of this instruction. However, specific action may still be required by ICW developers to comply with the requirements of this instruction.

Operating Systems

Summary

MS-DOS (Microsoft Disk Operating System). The de facto standard operating system for most personal computers, developed by Microsoft Corporation. MS-DOS is a single-user operating system for Intel Corp. 8088/80x86-based computers. It is installed on millions of computers worldwide and is used extensively for DoD ICW applications. MS-DOS-compatible operating systems are available from vendors other than Microsoft.

UNIX. Another de facto standard operating system. UNIX was originally developed by AT&T computer scientists for larger computers; it can accommodate multiple users and provide for running many processes at the same time. With the increase in computer memory and storage capabilities, UNIX is becoming more popular on small systems.

POSIX (Portable Operating System Interface for Computer Environments) (IEEE P1003.1,[3] FIPS 151). A standard mandated by the Federal Government and the DoD for multiuser system procurements. POSIX is modeled after the UNIX operating system and is available on a wide variety of hardware platforms.

OS/2. IBM Corp. operating system used primarily with IBM PS/2 computers. While this operating system has had some success in the private sector, it does not have widespread use within the Federal Government.

Macintosh. Proprietary operating system available only on Apple Computer's Macintosh computers. Its use in the DoD is limited to special applications.

Discussion

DoD uses the two predominant general-purpose operating systems: MS-DOS-compliant and POSIX-compliant operating systems. Because of the large purchase of Zenith Data Systems 80286-based computers under the Desktop II requirements contract and of Unisys Corp. 80386-based computers under the Desktop III requirements contract, DoD has a large installed base of microcomputer systems running MS-DOS. Many DoD ICW systems are therefore designed to run under MS-DOS. Future DoD requirements contracts will likely require some form of compatibility with these 80x86-based computers. POSIX is the operating system standard that is mandated for government multiuser systems, and computers bought under Desktop III and future requirements contracts will require POSIX compatibility as well. In the future, POSIX systems will provide improved portability between hardware platforms. OS/2 and Macintosh systems will probably see limited use within the DoD.

At present, the device interface standard described in MIL-STD-1379D, Appendix D applies only to MS-DOS systems. Plans are in place to upgrade the standard to include an interface for POSIX-compliant systems. Plans for providing OS/2 or Macintosh interface standards are not yet defined, but there is interest in including them as well.

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[3]The appendix lists where to obtain copies of the standards.

Recommendations

New ICW systems should be designed to run under either MS-DOS and its clones or a POSIX-compliant operating system. MS-DOS is the logical choice of ICW developers because the device interface standards described in MIL-STD-1379D can be used to provide portability. Because of the large installed base of existing MS-DOS computers, ICW applications designed for MS-DOS can be run at most Navy facilities without additional hardware.

The alternative to MS-DOS, especially for more powerful systems, is POSIX. The Federal Government is migrating toward POSIX-compliant operating systems, and it is likely that POSIX will predominate in the future. ICW applications developed to use POSIX may, therefore, have a longer life span than their MS-DOS counterparts.

OS/2 and Macintosh operating systems do not currently provide portability. Use of these operating systems should not be considered unless required features are available only on those computer systems.

Programming Languages

Summary

Ada (MIL-STD-1815A, FIPS 119, ISO 8652). The programming language designed and supported by the DoD. Ada is designed for structured programming and portability between target platforms. It is currently used mostly for weapons system development and embedded systems. Effective 23 February 1991, DoD Directive 5000.2 mandates the use of Ada for all new defense system development.

C Language (ANSI X3.159). A popular programming language for both MS-DOS and UNIX systems. It combines the features of a structured programming language with the power of assembly language. Many ICW training applications have been developed using C. Even though it is widely used, C has not yet been made into a FIPS and is not on the current list of recommended DoD high-order languages contained in SECNAVINST 5230.8 (DoN, 1982).

Pascal (FIPS 109, ISO 7185, ANSI X3.97). Another popular programming language that provides structured programming constructs. While it was a popular language in the 1970s and early 1980s, C has replaced it as the language of choice for most MS-DOS and UNIX applications.

FORTRAN (FIPS 069-1, ISO 1539, ANSI X3.9). An older language that is used primarily for scientific programming. FORTRAN is not a structured programming language, and its use for training system development is mostly limited to systems with heavy scientific or engineering requirements.

COBOL (FIPS 021-3, ISO 1989, ANSI X3.23). Designed and used primarily for data processing applications (e.g., payroll and personnel records). Its use for training system development is limited.

BASIC (FIPS 068). As its name suggests, BASIC is a basic programming language for developing software. Because of its simplicity, BASIC is frequently used for teaching computer programming, but it is seldom used for developing large application programs.

Discussion

According to SECNAVINST 5230.8, the list of approved high-order languages includes Ada, Pascal, FORTRAN, COBOL, and BASIC.

Although C is not yet on this list, it is the predominant language for microcomputer-based training system development because of its flexibility and its compatibility with both MS-DOS and UNIX. Because of its widespread use, many C software libraries and tools are available and useful for developing training systems.

Ada was designed by the DoD to provide a portable, structured programming environment for DoD systems. Because Ada is less flexible than languages such as C and because many Ada compilers require vast computer system resources, it has not gained wide acceptance in the commercial marketplace. Ada is not widely used for training system development, especially on microcomputers where the computer system resources are not usually available. The directive requiring its use for new defense systems development will probably result in greater use in training systems, although whether Ada is required for ICW development on small computers is not clear.

Pascal and BASIC are used for developing some training systems. FORTRAN and COBOL are not designed for applications such as ICW systems and therefore see limited use for training system development.

In addition to these languages, some newer languages such as C++, Smalltalk, and LISP are seeing increased use. The advantage of using these languages is that they are object-oriented. Object-oriented languages provide constructs not available in procedural languages such as C and Pascal, and their use can aid the development process for certain types of ICW. The languages also support constructs that are valuable when developing artificial intelligence applications. None has yet been approved as a Federal Government or national standard.

The software interface described in MIL-STD-1379D, Appendix D is language independent and, hence, is compatible with any of these programming languages.

Recommendations

Because the DoD now requires Ada for most new defense applications, it should be specified as the language of choice whenever possible. Because Ada is portable, it will provide greater flexibility when developing training systems for different hardware platforms.

For those applications where Ada is not a practical or appropriate option, C and its object-oriented extension, C++, offers the most flexibility and support from commercial vendors. The inclusion of C/C++ on the Navy's list of approved high-order languages is recommended.

Multimedia Peripheral Interfaces

Summary

MIL-STD-1379D. MIL-STD-1379D, Appendix D and the *IMA Recommended Practices for Multimedia Portability* (1990) provide the only known multimedia peripheral interface standard for MS-DOS non-windowing systems. MIL-STD-1379D provides a portable interface for videodisc players, graphic overlay cards, and pointing devices.

Microsoft Corporation's Application Programmer's Interface (API). The Microsoft API is a multimedia interface designed to work with Microsoft Windows 3.0 and 3.1. It provides a common software interface and data storage format for videodisc, the Musical Instrument Digital Interface (MIDI), compact disc (CD), videotape, digitizing devices, and scanners. Support for other devices will be added. Development of the Microsoft API is controlled by Microsoft Corp.

Discussion

Multimedia peripheral interfaces are standardized interfaces that provide a common software mechanism for controlling and communicating with many multimedia devices. Such multimedia devices include videodisc players, digital video devices, pointing devices, compact disc read-only memory (CD-ROM) devices, digital audio devices, MIDI music synthesis devices, and graphics overlay cards. Only two multimedia peripheral interfaces are available: the *IMA Recommended Practices for Multimedia Portability* (MIL-STD-1379D) for MS-DOS non-windowing systems, and the Microsoft API for MS-DOS systems using Microsoft Windows software.

The *IMA Recommended Practices for Multimedia Portability* (MIL-STD-1379D) standard is fully specified and can be used for training system development. Its drawbacks are that it is currently designed for non-windowing applications and that it supports only a few multimedia devices: videodisc players, graphics overlay cards, and pointing devices. The IMA plans to add support for windowing and for additional devices in the future, starting with the addition of an interface for digital audio devices.

The Microsoft API was released in the summer of 1991. While it offers support for windowing and a wider variety of multimedia devices, its development is controlled by Microsoft Corp., and application developers using the API must use Microsoft Windows 3.x, a proprietary product (see p. 13). It is becoming available for commercial use as this report goes to press. Since Microsoft Corp. is an IMA member, it is logical to expect that a reasonable migration path between MIL-STD-1379D and the Microsoft API may be established under the auspices of the IMA.

Recommendations

The software and hardware for MS-DOS non-windowing ICW systems that use videodisc players, graphics overlay cards, or pointing devices should be compatible with MIL-STD-1379D, Appendix D.

The use of the Microsoft API should be discouraged as long as it relies on Microsoft proprietary standards and products.

Integrated Multimedia

Summary

Compact Disc Interactive (CD-I) ("Green Book"). Philips Consumer Electronics Co. and Sony Corp. developed consumer-oriented system with digital full-motion video and digital audio. This standard cannot currently produce full-screen, motion video. It is a proprietary standard that is just now becoming commercially available.

Digital Video Interactive (DVI). Intel Corp. developed this integrated PC-based system including hardware and software that allows digital audio, still video, and full-motion, full-screen video. It uses proprietary hardware compression and decompression algorithms and proprietary storage formats for audio and video. Intel has suggested integrating the Joint Photographic Experts Group (JPEG) and Moving Pictures Expert Group (MPEG) standards (see p. 16) into DVI once they are available.

Compact Disc Video (CD-V) and Still Video Interactive (SV-I). CD-V and SV-I are two proprietary standards developed for video-only storage on a CD.

Discussion

Integrated multimedia products are single products that integrate digital audio and digital video technologies. Although many integrated multimedia products are available, none has been adopted as a standard and none has become the clear market leader or been recognized as a de facto standard.

Integrated multimedia technology is still in the development stage. Even though it shows great promise for the future, this technology has several problems that must be solved before it will gain widespread use:

1. Recording and playing back full-motion video is difficult with integrated multimedia technology. DVI technology can produce full-screen motion video, but CD-I currently cannot. Neither technology can record full-motion video in real time. Instead, each technology must compress and store video data on a frame-by-frame basis, making production of video sequences expensive.

2. Because integrated multimedia technology relies on data compression for storage of video and audio, the sounds and images that are produced are of lower quality than can be achieved with videotape or videodisc technology.

3. Even with data compression, digital audio and digital video require large amounts of digital storage. This problem should diminish in importance as high-storage CD technology becomes more popular.

Recommendations

Integrated multimedia products are still in development and the technology may change as a result. No clear standards have emerged that can be adopted.

Integrated multimedia products should be used with caution. Developers that want to use integrated multimedia products should be aware of the production, fidelity, and storage problems that exist. They should also realize that they may pay a price in terms of lack of portability until a standard emerges.

Graphic Display Software

Summary

Graphical Kernel System (GKS) (FIPS 120, ISO STD 7942, ANSI X3.124). GKS is a two-dimensional raster and vector graphics drawing standard. It is device independent and is available on MS-DOS and UNIX systems.

Programmer's Hierarchical Interactive Graphics System (PHIGS) (FIPS 153, ISO STD 9592, ANSI X3.144). PHIGS is a three-dimensional vector graphics standard for Computer Aided Design and Computer Aided Manufacturing (CAD-CAM) systems. It includes solid modeling and display list capability. It is device independent and provides a superset of functions to GKS.

Discussion

A major obstacle to application software portability is the lack of portability of graphic images. Many training systems and other applications use a single type of display device and are unable to run on hardware systems that use different display devices. This is true even on IBM-PC-compatible systems, where the Color Graphics Adapter (CGA), Enhanced Graphics Adapter (EGA), Video Graphics Array (VGA), and various other display devices are used. Even though there is downward compatibility from VGA to EGA and CGA, there is little compatibility between these and other display devices. In addition, higher resolution devices are seeing increasing use for special applications. Graphics developed for one device may not display properly on other devices. To solve this problem, the application software must be designed to support multiple display devices.

The easiest way to support multiple display devices is to use one of the graphics display standards described above. GKS is used for display of two-dimensional graphics, and PHIGS is used to display three-dimensional graphics. Both are accepted FIPS standards. The drawback to these standards is their performance characteristics. Using these standards requires more computer memory and can result in slower display of graphics images. These problems will lessen in importance with advances in processing and storage.

Another approach is to use graphics software packages for graphics display. These software packages provide routines that can draw graphics images on many display devices. For example, the Borland C and Microsoft C compilers, which are used on MS-DOS systems, both provide graphics libraries that support all major IBM-PC display devices. While these packages provide portability on MS-DOS systems, they do not provide portability to other operating system platforms.

MIL-STD-1379D does not address graphics portability, but it may do so in the future.

Recommendations

Currently, CGA, EGA, and VGA graphics constitute a de facto graphics standard in MS-DOS systems, since they predominate in those systems. To achieve a measure of graphics portability ICW developers can use either a de facto graphics standard or a graphics package that supports multiple display devices. True graphics standards such as GKS and PHIGS provide greater portability between operating systems, but their use may slow the operation of the training system to unacceptable levels and may require more hardware assets to operate than are commonly available.

Windowing Software

Summary

Microsoft Windows 3.x. Microsoft Windows 3.0 has become the de facto windowing and Graphical User Interface (GUI) standard for MS-DOS systems. Over 3 million copies have been sold since its introduction in April 1990. Version 3.1 was released two years later. Microsoft Windows 3.x is proprietary, but it is popular with commercial application software vendors.

Presentation Manager. The Presentation Manager is IBM's windowing software interface. It was developed for IBM's OS/2 operating system. It looks similar to Microsoft Windows 3.x.

Macintosh. The windowing capabilities of the Macintosh GUI first popularized this style of interface, and it is probably still the best known GUI.

X-Windows (FIPS 158). X-Windows is a portable, networked, windowing environment developed by the Massachusetts Institute of Technology. It is platform independent and runs on UNIX, POSIX, and MS-DOS systems. The source code for X-Windows is in the public domain

OPEN LOOK. OPEN LOOK is a GUI developed by UNIX International, which is an industry consortium led by Sun Microsystems and AT&T. It is based on the X-Windows environment.

Motif. Motif, developed by the Open Software Foundation (OSF), another industry consortium led by IBM, is another emerging GUI tool kit based on X-Windows.

XVT. XVT is a proprietary product developed by Advanced Programming Institute, Ltd. It provides a standard interface for developing GUIs that can run using several different GUI tool kits. Applications developed using XVT can run on several windowing systems, including OPEN LOOK, Motif, MS-Windows, and the OS/2 Presentation Manager.

Discussion

Windowing software is a form of user interface that runs application programs in windows on the screen. It provides an alternative to normal user interfaces that control what is displayed on the whole screen.

Two components make up windowing software: the windowing environment and the graphical user interface (GUI). The windowing environment allows the creation of windows, manages their

placement on the screen, and keeps track of user interactions with each window. The GUI provides menus, scroll bars, buttons, and other screen objects that the user manipulates to interact with a program. Microsoft Windows 3.x combines both components into a single product. X-Windows provides a windowing environment for UNIX, POSIX, and MS-DOS systems. If X-Windows is used, one of the X-Windows GUI packages must be selected for the user interface. Application software that is developed using XVT can run on systems that support OPEN LOOK, Motif, MS-Windows, or the OS/2 Presentation Manager. The Macintosh GUI is not an open standard and is not currently compatible with the others.

MIL-STD-1379D, Appendix D does not currently support windowing environments. Use of windowing software conflicts with those portions of MIL-STD-1379D that provide control for graphics overlay cards and pointing devices. The IMA has plans to add a windowing interface to the *IMA Recommended Practices for Multimedia Portability* standard (1990) and that interface should eventually be integrated into MIL-STD-1379, Appendix D.

Recommendations

If MIL-STD-1379D, Appendix D is used for controlling graphics overlay cards and/or pointing devices, windowing software should not be used.

If windowing software is used, X-Windows is the preferred windowing environment, since it is a FIPS standard and is supported on a wider variety of hardware platforms. MS-Windows may be usable for applications that are designed to run only on IBM-PC-compatible machines.

Optical Disc Technology

Summary

Videodiscs. Philips and Sony developed this standard for 12-inch reflective optical videodiscs. The sound and video are stored in analog format. Two formats exist for storing audio and video on videodiscs. Constant Linear Velocity (CLV) discs contain more data (pictures and audio), but they cannot support some of the more advanced videodisc features such as frame search. Constant Angular Velocity (CAV) discs provide more features but have limited data storage capacity. Videodisc technology is a mature technology and is well understood.

Compact Disc Digital Audio (CD-DA) ("Red Book"). This standard, developed by Philips and Sony, defines the format of digital audio tracks on a compact disc. It is highly standardized and is the format used for consumer audio compact disc media and player technology.

Compact Disc Read-only Memory (CD-ROM) ("Yellow Book") (ISO 10149). This standard, developed by Philips and Sony, defines the format of logical disc sectors on a compact disc.

High Sierra Format (ISO 9660). This format defines MS-DOS-based file and directory formats for CD-ROM.

Rock Ridge. The Rock Ridge Technical Group is a consortium that includes Sun Microsystems, Hewlett-Packard Co., Apple Computer, and Interactive Systems. This technical

working group is developing extensions to ISO 9660 to support other operating systems (e.g., POSIX).

CD-ROM Extended Architecture (CD-XA). Microsoft Corp. developed this extension to ISO 9660, which provides storage of VGA quality graphic images.

CD-Rx. The U.S. Intelligence Community developed this portable CD-ROM file and directory format specification for MS-DOS, UNIX, and Macintosh systems. A draft document is being developed.

Write Once Read Many (WORM) Optical Disc. Five incompatible standards (different sizes and media types) are under consideration by ANSI. No clear winner is likely to appear soon.

Read/Write Optical Disc. The ISO/SC3 and ANSI X3B11 standards groups have been working to develop a standard for Read/Write optical discs based on 5-1/4 inch Magneto Optical disc technology. This standard is expected to be adopted soon.

Discussion

Many products and standards have been developed for optical disc technology. The standards can be divided into those dealing with:

1. Analog videodiscs.
2. Audio compact discs (CD-DA).
3. Computer file formats on CDs (CD-ROM, High Sierra, Rock Ridge, CD-XA, CD-Rx).
4. WORM and Read/Write optical discs.

Determining which standards apply for application programs using optical discs depends on the specific optical disc technology that is used.

Of these technologies, the two that are currently used most often for ICW systems are videodiscs and CD file storage. MIL-STD-1379D, Appendix D provides a standard interface for videodisc players. The accepted standard for MS-DOS file formats is ISO 9660. The use of ISO 9660 for storage of data files is compatible with MIL-STD-1379D, Appendix D.

The standards for read/write optical discs are still being developed, and no clear standard has yet emerged.

Recommendations

When working with videodisc players on MS-DOS systems, the interface standard defined in MIL-STD-1379D, Appendix D should be used. When CD-ROM drives are used for storage of MS-DOS files, ISO 9660 should be used. Other optical disc standards should be used where appropriate.

Data Storage and Compression

Summary

Computer Graphics Metafile (CGM) (FIPS 128, ISO STD 8632, ANSI X3.122). This is a device-independent storage format for description of two-dimensional graphical images. It is mature and part of the CALS standard.

Initial Graphics Exchange Specification (IGES) (MIL-D-28000 [DoD, 1987], ANSI Y14.26M). IGES defines a standard graphic file format for representation and transfer of three-dimensional graphic images and product definition data for CAD/CAM systems. It is mature and is part of the CALS standard.

Musical Instrument Digital Interface (MIDI). This music industry standard provides data formats and transmission specifications for musical notation.

Joint Photographic Experts Group (JPEG). This standard, currently being developed by an ISO working group, provides still video format compression and decompression up to 20:1. A draft standard is available and a final standard is expected soon. Several commercial implementations have been done (e.g., by NeXT, Inc. and Sun Microsystems).

Moving Picture Expert Group (MPEG). This standard, currently being developed by an ISO working group, provides audio and motion video compression and decompression. The standard is at least two years from acceptance.

Multimedia and Hypermedia Coding Expert Group (MHEG). This standard, being developed by an ISO working group, defines data representation and interchange mechanisms for multimedia objects including text, graphics, audio, still images, and motion video. It will be several years before this standard is available.

Discussion

As with optical disc technology, a variety of standards are related to data storage and compression. The standards can be divided into those dealing with:

1. Graphics data storage and compression (CGM and IGES).

2. Music (MIDI).

3. Compression of video images (JPEG, MPEG, and MHEG).

Both the graphics standards and the music standard are well defined and have been in use for years. The two graphics data storage standards correspond to the two graphics display standards discussed previously. Typically, the CGM graphics storage standard for two-dimensional graphics is used with the GKS graphics display standard, and the IGES graphics storage standard for three-dimensional graphics is used with the PHIGS graphics display standard.

While the MIDI standard is not widely used in training system development, it has been used in the music industry for several years, especially for electronically programmable keyboards and

instruments. The video compression and storage standards are still being developed, and, while draft versions of some of these standards are available, it will be several years before they are widely used in the commercial sector.

MIL-STD-1379D does not currently support any particular data storage and compression standard, although it is compatible with the graphics and music standards. The IMA is in the process of developing a digital audio standard that will include data storage and compression standards for audio. The IMA digital audio standard will eventually be incorporated into MIL-STD-1379, Appendix D.

Recommendations

If GKS or PHIGS standards are used for display of graphic images, then CGM or IGES should be considered for storage of the graphic images. The MIDI interface standard should be considered when working with digitized music. Other data storage and compression standards are not yet well enough defined.

Document Processing

Summary

Office Document Architecture (ODA) (ISO 8613). This office publishing standard is used primarily for general-purpose office documents and reports. It is not widely used for typographic quality documents and brochures.

Standard Generalized Markup Language (SGML) (FIPS 152, ISO 8879). SGML is an architecture for describing document information in a standard notation. It includes representations for text, graphics, tables, and other multimedia objects.

Computer-aided Acquisition and Logistic Support (CALS). CALS is a digital documentation standard developed by the U.S. military for text and graphics. It is described in MIL-STD-1840B, *Automated Interchange of Technical Information*. CALS has been adopted by the DoD for engineering and technical documentation related to weapons systems. The CALS standard includes the SGML, IGES, and CGM standards and is referenced in MIL-STD-1379D, Appendix C.

Authoring Instructional Materials (AIM) (Vogt, Robinson, Taylor, & Wulfeck, 1989). AIM is a Navy research project designed to automate the format and content requirements of curriculum development using MIL-STD-1379 and DOD-HDBK-292 (DoN, 1986). The goal of AIM is to provide the Navy with automated tools for designing, developing, producing, and maintaining curriculum materials. AIM incorporates the CALS standards for formatting and storage of technical documentation. Prototype AIM systems are currently being used at several Navy training facilities.

Discussion

Document processing standards were reviewed to see how they relate to ICW. While document processing is not directly related to ICW, ICW systems that can access information stored in

document databases will become important as more technical information is stored in those databases.

Of these standards, the Navy currently uses AIM and CALS. AIM is still a prototype system, but in the future it should provide a good automated system for developing training materials. CALS is used throughout the DoD for technical documentation related to military systems. As more technical information is stored in CALS format, it will be usable by ICW systems that can access CALS databases.

Recommendations

As AIM becomes available, it should be used to aid development of curriculum materials. The CALS standard can be used to standardize technical documentation. When designing ICW systems, developers can look into using CALS data for some of the subject matter.

Conclusions and Recommendations

Improving the portability and maintainability of ICW systems should be among the goals in the development of these systems during the next decade. Developing systems that are tied to a single hardware platform is neither necessary nor cost effective. The use of standards when developing ICW training systems improves the portability and maintainability of such systems.

The DoD, recognizing the need for courseware portability, adopted the IMA *Recommended Practices for Multimedia Portability* as part of MIL-STD-1379D. The standard provides portability for MS-DOS-compatible systems that use videodisc players, graphics overlay cards, and pointing devices. Recognized national and international standards organizations have developed other standards that provide portability for computer devices not covered by MIL-STD-1379D, Appendix D.

Based on the need for improved portability of ICW systems, the Navy ICW community should consider the following recommendations:

1. Plan ICW systems that can operate using a variety of products. Do not tie ICW policy to proprietary products or interfaces.

2. Design ICW training to use existing Navy computer hardware. ICW training that is compatible with Desktop II and Desktop III computers and UNIX/POSIX workstations will see increased use within the Navy and will avoid the purchase of new, expensive computer hardware.

3. Adopt MIL-STD-1379D to achieve portability of MS-DOS-compatible ICW systems that use videodisc players, graphics overlay cards, and pointing devices. Require ICW developers and computer system manufacturers to use the interface standards described in MIL-STD-1379D, Appendix D.

4. Support continued development of the *IMA Recommended Practices for Multimedia Portability* and MIL-STD-1379D, Appendix D. As the standard is expanded in the future, portability for more multimedia devices will be supported.

5. Adopt other national and international standards when they apply to components of ICW systems. Request that ICW developers and computer system manufacturers use appropriate standards whenever possible.

6. Avoid using new multimedia technologies for production ICW systems until they are fully developed. Technologies such as DVI, JPEG, MPEG, and read/write optical discs provide multimedia capabilities that were not previously available, but they still have some technical deficiencies that could cause problems for ICW developers.

7. Use DoD and Navy document processing standards (CALS and AIM) where appropriate for ICW development.

Other activities can be undertaken by those who set the Navy's policies on ICW to help Navy training developers in their efforts. These suggestions should be evaluated for their feasibility and usefulness before being implemented.

1. Develop a user interface style guide for ICW training systems.

2. Develop guidelines for developing portable applications.

3. Develop hardware selection guidelines for training system computers and multimedia components.

4. Establish a technology advisory board to evaluate new technology for stability, portability, and usefulness.

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Appendix

Sources of Information

Sources of Information

For ANSI/ISO standards:

American National Standards Institute
1430 Broadway
New York, NY 10018
Phone: (212) 642-4900

For FIPS and other technical information:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Phone: (703) 487-4650

For IEEE standards:

IEEE Service Center
445 Hoes Lane
Piscataway, NJ 08854
Phone: (201) 562-3800

For IMA standards and compatibility information:

Interactive Multimedia Association Compatibility Project
9 Randall Court
Annapolis, MD 21401
Phone: (410) 626-1380

For ISO draft standards:

Computer and Business Equipment Manufacturers Association
Director, X3 Secretariat
311 First Street, NW
Suite 500
Washington, DC 20001
Phone: (202) 737-8888

For MIL-STD and MIL-HDBK publications:

Commanding Officer
Naval Publications and Forms Center
5801 Tabor Avenue
Philadelphia, PA 19112

For information on Motif:

Open Software Foundation
11 Cambridge Center
Cambridge, MA 02142

For NIST Application Portability Profile information:

National Institute of Standards and Technology
Computer Systems Laboratory
225 Technology Building, Room B266
Gaithersburg, MD 20899
Phone: (301) 975-3275

For the X/OPEN portability guide:

Elsevier Science Publishers Co., Inc.
P.O. Box 211
Grand Central Station
New York, NY 10163

For information on XVT:

Advanced Programming Institute, Ltd.
Box 17665
Boulder, CO 80308
Phone: (303) 443-4223

For printouts of standards:

Global Press
2625 Hickory Street
Santa Ana, CA 92707
Phone: (800) 854-7179 or (714) 261-1455

For standards searches:

NASA Industrial Application Center
3716 S. Hope Street
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